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ARTICLE

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3D laparoscopic prostatectomy: results of multicentre study

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ABSTRACT

Introduction: Three-dimensional laparoscopic prostatectomy (3D LRP) is a potentially cost-effective option for robot-assisted laparoscopic prostatectomy (RALP). Results for two-dimensional LRP and RALP are well documented; however, little has been published on the outcomes of 3D LRP. Our objective was to report the perioperative and short-term results of 3D LRP in a multicentre study.

Materials and methods: In total, 496 unselected men with prostate cancer underwent 3D LRP by three surgeons between December 2013 and December 2018. Median age was 64 (43–76) years. Median prostate-specific antigen (PSA) was 7.9 (0.7–148) ng/ml. Preoperative and perioperative data and complications according to the Clavien–Dindo classification were collected. PSA and continence results were reported at 3 and 12 months postoperatively. Data were analysed with IBM SPSS statistics (25).

Results: Pathological Gleason score was 6 in 29%, 7 in 55.4%, 8 in 9.1%, 9 in 5.2% and 10 in 1.2% of patients. Pathological tumour classification was T2c in 59.5%, T3a in 19.5% and T3b in 10.9% of cases. Positive surgical margins occurred in 27.2%. Lymphadenectomy was performed in 36.3%, with positive lymph nodes in 11.8%. Median operative time was 137 (78–334) min and median blood loss 200 (10–1100) ml. Clavien–Dindo IIIa and IIIb complications occurred in 6.9% and 1.6%, respectively. At 3 and 12 months postoperatively, 90.2% and 91.4% of patients, respectively, had PSA <0.2 ng/ml, while 77.1% and 87.7% of patients were completely dry or using a maximum of one pad daily.

Conclusions: 3D LRP shows promising results, comparable to similar studies published on RALP.

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Introduction

For decades, open retropubic prostatectomy (ORP) was the predominant method in the surgical treatment of prostate cancer [1]. Although the basic principles of the open operative technique have remained unchanged over time, continual refinements of the technique have facilitated improvements in outcomes [1,2]. The open operative technique is, however, hampered by its invasive nature. It is therefore understandable that the quest for less invasive surgery inspired the development of laparoscopic prostatectomy (LRP) [3,4]. The laparoscopic technique fulfilled its promises of reduced perioperative blood loss and reduced postoperative pain and hospitalization, while expert surgical hands were able to maintain the same quality of surgery as with the open technique [5]. It was not until the introduction and dissemination of robot-assisted laparoscopic prostatectomy (RALP) that minimally invasive prostatectomy challenged the position of ORP as the gold standard for operative treatment of prostate cancer [6]. RALP was rapidly adopted in Western countries owing to its gentle learning curve and seemingly superb operative outcomes compared to open radical prostatectomy [6,7].

However, this revolutionary technique was adopted without rigorous scientific evaluation. Later randomized and population-based studies have shown that RALP and open radical prostatectomy have similar short- and long-term outcomes. Reduced admission times and blood loss are associated with RALP, but that robot-assisted technique results in considerably higher treatment-related costs [8,9]. The evolution of surgical treatment for localized prostate cancer demonstrates that minimal invasiveness is an advantage that is here to stay, and the challenge for the future will be to contain the treatment-related costs.

The main advantages that enabled easy adoption of robot-assisted surgery are its three-dimensional (3D) vision and the human wrist-like articulation of the endoscopic instruments. In addition, RALP might offer better ergonomic conditions for surgical team compared to both ORP and 3D LRP. While articulated laparoscopic instruments – other than those of Da Vinci – remain scarce and cumbersome, several 3D endoscopic camera systems have emerged. To date, few

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studies have reported the outcomes of 3D LRP [10–12]. The improved depth of perception with 3D imaging should enhance the surgeon's performance and offer an advantage when completing complex laparoscopic procedures [13]. With these potential advantages in mind, 3D LRP was initiated in four Finnish centres that had no access to a robotic system. To our knowledge, no previous multicentre studies have reported the results of 3D LRP. Herein, we report the perioperative and short-term results of the initial 496 3D LRP operations in four centres.

Materials and methods

A total of 496 unselected patients with localized prostate cancer underwent 3D LRP at four different Finnish central hospitals between 19 December 2013 and 21 December 2018. Of this population, 200 patients underwent surgery at Seinäjoki at South Ostrobothnia, 152 at Pori in south-west Finland, 113 patients at Jyväskylä in central Finland and 31 at Kokkola in Central Ostrobothnia.

To obtain qualitative data on these 3D LRPs, the local databases were combined. The operations were performed by three surgeons in the proportions of 40.3% (200), 29.1% (144) and 30.6% (152) of the cases. None of the surgeons had previous experience with 3D LRP or 2D LRP. All surgeons had some experience with 2D laparoscopic kidney surgery before the survey. Two surgeons had previous experience with prostate surgery, one with both RALP and ORP and one with ORP only. The operations were performed with fourth-generation glasses and 3D-vision technology using an Olympus Endoeye Flex 3D videoscope. The basic principles of the operations were uniform, although some variance between different centres and surgeons occurred over the 5 year duration under study.

3D LRPs were performed either extraperitoneally with the University of Leipzig technique or transperitoneally with modification of the Vattikuti Institute prostatectomy method [6,14]. The decision to pursue lymphadenectomy was based on the risk stratification, which was evaluated using the D'Amico risk classification [15] or Memorial Sloan Kettering Cancer Center pre-radical prostatectomy nomogram. Vesicourethral anastomosis was performed with the Van Velthoven technique [16] and seminal vesicles were removed. The catheterization time was 7–14 days, based on the surgeon's decision, which was made intraoperatively. No routine cystography was carried out before removing the catheter.

Preoperative and intraoperative data, such as patient age, PSA, Gleason category and T classification, were collected. Intraoperative and perioperative variables, such as the duration of the surgery (min), blood loss (ml), nerve sparing and the length of hospital stay, were registered. After surgery, the Gleason category TNM classification, positive surgical margin (PSM) and lymph-node status were collected based on the pathologist's report. The patients were monitored during two subsequent control visits, which occurred approximately at months 3 and 12, depending on the schemes in the different hospitals.

At the control visits, the PSA was checked, and patient continence was evaluated based on self-report collected from the medical records. Urinary continence was classified according to four groups: continent (no pads), single day-time safety pad (night-time continent and most of the day-time), two or more pads (pads on day-time but night-time continent) or totally incontinent (pads on both day- and night-time). Surgical complications were assessed with the Clavien–Dindo classification of surgical complications at a cut-off point of 3 months from the operation [17]. Complications were assessed from the patients' medical records. Postoperative contacts with the emergency room (ER) or acute appointments with the general practitioner were evaluated and classified.

The data were analysed using IBM SPSS statistics version 25. The median results are presented with ranges (minimum–maximum) in the text, and in the tables with ranges and quartiles.

Results

The median age of the patients was 64 years (43–76 years). The median PSA at the time of diagnosis was 7.9 ng/ml (0.7–148 ng/ml). Preoperative histological classification according to EAU risk groups were as follows: Low risk (44.6%), intermediate risk (40.3%) and high risk (15.1%). The most common primary tumour was T1c, in 43.2% of the patients (Table 1). Nerve sparing (NS) was done in 177 patients (35.7%) on both sides, in 143 cases (28.8%) NS was unilateral and in 61 cases (12.3%) there was no attempt at NS, or the neurovascular bundles were resected owing to wide excision. In 115 patients (23.2%), the data were not available.

The median total operative time was 137 min (78–334 min) and the median blood loss was 200 ml (10–1100 ml). The median operative time was 120 min (78–303 min) when the operation was performed without lymphadenectomy and 180 min (78–344 min) with lymphadenectomy. Lymphadenectomy was done in 180 patients (36.3%). The vast majority (91.1%) of the patients were discharged by the third postoperative day (Table 2).

Table 1. Patient characteristics. Patients underwent 3D LRP in four centres in Finland between 2013 and 2018.

No. of patients	496
Age (years), median (range) [Q1–Q3]	64 (43–76) [59–68]
Tumour clinical characteristics	
PSA (ng/ml), median (range) [Q1–Q3]	7.9 (0.7–148) [5.5–11.7]
Gleason score (biopsy), % (*n*)	
6	44.6 (221)
7	40.3 (200)
8	10.5 (52)
9	3.4 (17)
10	1.2 (6)
Primary tumour (T), % (*n*)	
T1c	43.2 (214)
T2	39.3 (195)
T3	17.5 (87)

PSA: prostate-specific antigen.

Table 2. Perioperative data. Patients underwent 3D LRP in four centres in Finland between 2013 and 2018.

	Median (min–max) [Q1–Q3]
Operative time, all cases (min)	137 (78–344) [110–170]
Operative time without lymphadenectomy (min)	120 (78–303) [102–145]
Operative time with lymphadenectomy (min)	180 (97–344) [147–190]
Estimated blood loss (ml)	200 (10–1100) [100–300]
	% (*n*)
Clavien–Dindo at 3 months	
Grade I	8.3 (41)
Grade II	4.5 (22)
Grade IIIa	6.9 (34)
Grade IIIb	1.6 (8)
Grade IVa	0.2 (1)
Grade V	0.2 (1)
Release day from hospital (days after surgery)	
Day 1	39.9 (198)
Day 2	41.1 (204)
Day 3	10.1 (50)
Total patients discharged from hospital during first 3 postoperative days	91.1 (452)

Table 3. Oncological results. Patients underwent 3D LRP in four centres in Finland between 2013 and 2018.

	% (*n*)
pT	
T2a	8.7 (43)
T2b	1.2 (6)
T2c	59.5 (295)
T3a	19.5 (97)
T3b	10.9 (54)
T4a	0.2 (1)
pG	
6	29 (144)
7	55.4 (275)
8	9.1 (45)
9	5.2 (26)
10	1.2 (6)
Surgical margins	
All cases	
Negative	72.8 (361)
Positive	27.2 (135)
pT2	
Negative	80.2 (276)
Positive	19.8 (68)
≥pT3	
Negative	55.9 (85)
Positive	44.1 (67)
pN	
Negative	88.2 (141)
Positive	11.8 (19)

Table 4. Functional and oncological results after surgery. Patients underwent 3D LRP in four centres in Finland between 2013 and 2018.

	% (*n*)
Continence	
3 months	
Dry	36.9 (170)
Single day-time pad	40.2 (185)
Sheath (continent overnight)	22.2 (102)
Sheath (incontinent)	0.4 (2)
12 months	
Dry	67.3 (281)
Single day-time pad	20.4 (85)
Sheath (continent overnight)	11.5 (48)
Sheath (incontinent)	0.7 (3)
PSA (ng/ml)	
3 months	
< 0.2	90.2 (441)
≥0.2	9.8 (48)
12 months	
< 0.2	91.4 (414)
≥0.2	8.6 (39)

The most common pT classifications were T2c (59.5%), T3a (19.5%) and T3b (10.9%). Corresponding Gleason classifications were G7 (55.4%), G6 (29%) and G8 (9.1%). PSM occurred in 27.2% of the cases. In pT2, the PSM was 19.8%, with ≥ pT3 in 44.1% of the cases (Table 3).

Clavien–Dindo grade IIIa complications occurred in 6.9% (34 cases) and IIIb complications in 1.6% of the patients (eight cases). The grade IIIa complications were lymphoceles, leakage of anastomosis or problems with catheters. These complications were treated with a change of catheters under spinal anaesthesia or insertion of a drainage tube by the intervention radiologist. There was one fascia rupture and inherniation of the small intestine to the laparoscopic port wound, which was treated under spinal anaesthesia. The grade IIIb complications held surgical site haematomas or lymphoceles, which required reoperations. There were two injuries to the sigmoid colon and one injury to the J-pouch, which required reoperation. During the surveillance period, one patient required intensive care unit treatment as a result of postoperative infection of abdominal subcutaneous tissue, which occurred 7 days after the primary operation. The infection required extensive revision and vacuum-assisted closure. One patient died from acute myocardial infarction during the 3 month surveillance period. This event did not occur during the perioperative phase in the hospital.

At the 3 and 12 month control visits, 90.2% and 91.4% of patients had PSA <0.2 ng/ml, respectively. Patients having hormonal or salvage radiotherapy for biochemical recurrence at 3 months were included in the analysis at 12 months. At the first and second visits, 77.1% and 87.7% of the patients were completely dry or were using a maximum of one daily pad, respectively (Table 4).

Discussion

Since its introduction in 2008, RALP has rapidly become the predominant technique for prostate cancer surgery in Finland [18]. The use of expensive treatments is restricted in the publicly funded Finnish healthcare system, and robot-assisted surgery is centralized in university hospitals.

Motivated by these restrictions, financial incentives and the introduction of high-quality 3D laparoscopic systems, we started performing 3D LRPs in four Finnish central hospitals with no access to a robotic system. Between December 2013 and December 2018, 496 operations were performed. Herein, the initial perioperative and short-term oncological and functional outcomes are reported.

RALP has become the preferred method of prostate cancer surgery in most centres, although its oncological and functional results are not superior to those of open or 2D laparoscopic surgery [5,8,19]. However, in a 2021 study by Stolzenburg et al. that compared RALP and 2D LRP, the early continence recovery was better in the RALP group [20]. With the advent of 3D laparoscopic systems, a few small series have been published reporting the outcomes of 2D versus 3D LRP. In the study by Aykan et al., an experienced surgeon was found to have both shorter operative time (OT) and shorter vesicourethral anastomosis time (VUAT) in 3D LRP compared to 2D LRP. The blood loss in that study was significantly lower with 3D vision and the early continence better in the 3D LRP group [21]. On the other hand, Kinoshita et al. found no benefit to VUAT of 3D vision in prostatectomy [22]. For their part, Bove et al. compared 3D LRP to 2D LRP with a total number of 86 patients. In their study, both the OT and VUAT were significantly lower with 3D LRP. The continence rates after surgery were favourable to 3D LRP, but not statistically significantly so [11].

Thus far, no reports on the direct comparison of 3D LRP versus RALP have been published. For this reason, the benefit of this study is that it reports real-life data on 3D LRP performed in the context of unselected patients in centres and with surgeons with no prior experience of endoscopic prostate surgery. Comparison of the outcomes reported here with previously reported RALP series offers a critical perspective on the feasibility of 3D laparoscopic prostate surgery during an era when conventional LRP is increasingly considered a thing of the past.

Given the dominant role of RALP in most Western countries, including Finland [18], the outcomes of other operative techniques should be compared against it. Only if a novel technique shows comparable oncological and functional outcomes with existing methods and comes with some potential advantages, such as cost savings, would it be feasible to continue to promote such techniques. Functional and oncological results, operative time, median blood loss and length of hospital stay in our series are comparable to those in previously published large RALP series [6,18,23], which implies a comparable need for hospital resources for these operative techniques. Without a need for major upfront capital investment and subsequent service fees, it therefore seems obvious that the direct treatment-related cost remains lower for 3D LRP compared to RALP. However, since we have not performed economic calculations of treatment expenditures in this report, this conclusion remains speculative. In addition to the costs, another reason for performing 3D LRP in central hospitals rather than referring patients to the university hospitals for RALP is to maintain a large enough degree of experience for the laparoscopic team, which also performs kidney surgery.

The reported continence results – 77.1% fully continent or needing a maximum of one safety pad at the first control visit (3 months) and 87.7% at the second control visit (8–12 months) – are slightly inferior to those reported earlier by centres of excellence [24,25]. They are, however, comparable to those reported in both a Finnish and a Swedish RALP series [18,26], suggesting that 3D LRP and RALP result in similar outcomes. In a similar fashion, early oncological outcomes of this series are like those earlier reported at the commencement of robot-assisted prostatectomies in Finland. During the course of this series, the tendency to operate on low-risk cancers diminished. However, as many as 30.6% and 15.2% of those patients had pT3a tumour and lymph-node metastases, respectively. These figures are similar to those reported earlier in a larger Finnish multicentre RALP series, and reflect the local standard of care [18].

Likewise, the PSM rate of 27.2% in this study is similar to that previously reported [18]. However, this PSM is comparatively high compared to the figures reported elsewhere, which may partly reflect a learning curve during initiation of a new technique [27]. In addition, in this series, 9.8% of the patients had detectable PSA (>0.2 ng/ml) at 3 months post-surgery. This number is higher than previously reported in Finland and may reflect the trend for operating on patients with more advanced disease [18].

In regard to postoperative complications, earlier series on extraperitoneal 2D LRP reported complications needing early postoperative reinterventions in 3.05% of cases [5]. Similarly, a large single-surgeon RALP series reported an early complication rate of 4.3% [25]. In a large meta-analysis of RALP studies, complications such as lymphocele/lymphorrhoea occurred in 3.1% (1.2–29%) of cases, urine leakage in 1.8% (0.1–6.7%) and reoperation in 1.6% (0.5–7%) of patients [23]. In our series, during the first 3 postoperative months, 6.9% of the patients required radiological, endoscopic or surgical intervention under spinal anaesthesia, denoting a Clavien IIIa complication, and IIIb complications occurred in 1.6% of the patients. The complication frequency in our report is therefore comparable to the rates in earlier reports on 2D LRP and RALP. In the future, it is likely that the complication frequency of 3D LRP will diminish once the learning curve plateaus [25]. However, this will require continual and systematic effort, such as described by Cathcart et al. [28]. The learning curve was not analysed here, but it has been shown that it takes as many as 60 cases to reach a plateau in operative time, whereas no plateauing in PSM was seen in 200 cases [27].

Preoperative and postoperative potency was not systematically recorded in all the centres, and, therefore, we chose not to report potency results in this study, which is a clear limitation. Another deficiency in our study is the incomplete documentation of NS. Continence was evaluated by patients' self-report collected from medical records and, unfortunately, a validated questionnaire was not routinely used during the survey, which is a true limitation. The self-reported evaluation of the continence is likely to be biased towards better

outcomes. However, the evaluation was conducted as truly as possible and in case of difficulty in interpretation a worse continence result was taken into account. Nearly 45% of the operated men had Gleason 6 cancer based on diagnostic biopsies. Such low-risk cancers would nowadays be managed mainly with active surveillance, which may limit the generalizability of our results to current clinical practice. However, most patients with Low-risk cancers were young, had many positive cores in biopsies or were not willing to start or to continue previous active surveillance. In the final pathologist's report, the proportion of Low-risk cancers decreased from 44.6% (221) to 29% (144), which shows clearly the diagnostic challenges encountered during the survey.

The main objective of this investigation was to report the early real-life experience of 3D LRP in a large enough cohort of unselected consecutive patients to evaluate the feasibility and safety of this new technique as a viable alternative to RALP. It must be noted that, in this study, none of the surgeons had any previous experience with 3D LRP or 2D LRP, no other surgical method was used during the period and there was no patient selection or exclusion, as all consecutive patients from the first case were included in the analysis.

Overall, the present data indicate that 3D LRP shows similar outcomes to those reported previously for 2D LRP and RALP. The immediate perioperative parameters of 3D LRP were identical to those in earlier prostatectomy series. For successful continuation of this technique, however, continual and systematic quality assurance efforts are necessary. To directly compare 3D LRP with RALP, in terms of outcomes and cost analysis, a study in a randomized prospective setting is necessary, and such efforts are currently under way.

Conclusion

3D LRP is an alternative to RALP, with known benefits of minimal invasiveness. It shows feasible oncological and functional results. In our study, implementation of the method led to consistent operative outcomes comparable to those of similar studies on RALP implementation. However, efforts are needed to further improve the functional and oncological results and to reduce the risk of complications to attain the results achieved using RALP in centres of excellence.

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Disclosure statement

T.J. Murtola is a consultant for Astellas, Janssen-Cilag, Novartis, Sanofi and Ferring. He reports receiving speakers' bureau honoraria from Astellas, Novartis, Sanofi, Merck, Pfizer and Janssen-Cilag, and congress participation at the expense of Janssen-Cilag and Pfizer.

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